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ABSTRACT TITLE: Simulation studies of vapor bubble generation by short-pulse lasers

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BIOGRAPHY: Dr. Amendt has contributed to many areas of Theoretical Physics including inertial confinement fusion, x-ray lasers, channeling radiation, galactic dynamics, accretion disc theory, plasma physics, and potential theory. His current interests comprise radiation-hydrodynamical modeling of laser-plasma interactions in fusion experiments, laser-assisted stroke treatment, and dynamics of laser-irradiated melanin granules.

BRIEF ABSTRACT: In various short-pulse laser medical applications, the formation of vapor bubbles can occur. Understanding the dynamics of vapor bubble generation is a necessary step in developing and optimizing laser-based medical therapies. To this end, LLNL has been conducting experiments in vapor bubble generation by depositing laser light in an aqueous dye solution near a fiber-optic tip. We present modelling results of the experiment, both in one- and two-dimensions. Good agreement between simulations and data for bubble evolution is found.

Another important arena for vapor-bubble generation is short-pulse laser interactions with melanosomes. We present results from our modeling effort in understanding the onset of bubble generation and observed high Mach number shock waves.

ABSTRACT

In various short-pulse laser medical applications, the formation of vapor bubbles can occur. Understanding the dynamics of vapor bubble generation is a necessary step in developing and optimizing laser-based medical therapies. To this end, LLNL has recently conducted a series of vapor bubble experiments using short-pulse lasers which deposit energy into an aqueous dye solution via an optical fiber. Comparison of the observed vapor bubble evolution with modelling is the main subject of this presentation.

Our basic modeling tool is the LATIS (LAser TISsue) computer code. This two-dimensional, time-dependent program includes the processes of laser propagation, thermal transport, material effects and hydrodynamics. Full coupling of these processes is included in the simulations. We use LATIS in both one- and two-dimensions for modeling vapor bubble experiments. Comparison of the one-dimensional simulation results with experiment show a persistent pattern of larger bubble radius and longer expansion times than observed. This discrepancy leads us to consider two-dimensional simulations with LATIS which include the effects of nonradial motion. Good agreement is found between the two-dimensional simulations and data for vapor bubble behavior.

Another example of vapor bubble generation is found in laser-irradiated melanosome structures in Retinal Pigment Epithelium cells. Experiments with bovine melanosomes conducted by Lin and Kelly[1] show the occurrence of micron-scale vapor bubbles and strong precursor shocks with Mach numbers ≈ 2. Of particular interest is an understanding of the threshold conditions for bubble generation and the mechanism for strong shock generation. We have investigated with LATIS various scenarios for laser absorption by the melanosome and sub-melanosome structures in order to explain the observed high Mach numbers. Two possible explanations include an enhanced melanosome absorption coefficient on the order of 6000 cm^{-1} or 15 nm-scale sub-melanosome absorption centers responsible for generating strong shock waves.

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[1]Lin and Kelly, SPIE **2391**, 294 (1995)

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